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Valuing nature-conservation interests: a case study on agricultural floodplains

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Abstract

1. Agricultural land drainage schemes in areas previously liable to frequent flooding by rivers were once an important element of government support for British farmers. More recently, however, changing priorities in the countryside, concern about environmental quality and perceptions of increased flood risk, have prompted a re-appraisal of land management options and policies for floodplain areas. The consequences of future decisions need to be fully assessed, which requires the combined perspectives of social and natural sciences.

2. An important part of this process is to establish the "value" of the nature-conservation assets within an area. This value can then be compared with data for other ecosystem services, to identify management priorities under different future scenarios. However, there is little consensus on how to perform such an evaluation. In this paper, we assess seven methods of valuing nature-conservation interest and compare their utility.

3. Five agricultural land drainage schemes across England were selected for study. The current land-use was determined and four different scenarios of future management were developed. The land-use and habitats predicted under each scenario were assessed using seven methods of determining value, namely: Ecological Impact Assessment method, reserve-selection criteria, target-based criteria, stakeholder-choice analysis, reserve-selection criteria guided by stakeholders, agri-environment scheme costing, and contingent valuation. The first three methods derive values based on predefined priorities, the next two use stated preferences of stakeholders, and the last two derive monetary values based on revealed and expressed preference respectively.

4. The results obtained from the different methods were compared. The methods gave broadly similar results and were highly correlated, but each method emphasised a different aspect of conservation value, possibly leading to different outcomes in some circumstances. The advantages and disadvantages of each method are discussed.

5. *Synthesis and applications.* This study has shown that seven different valuation methods, although all giving significantly correlated results, resulted in seven different rankings of nature-conservation value for the twenty-five situations studied. This difference occurred in spite of the situations all being in the same landscape type and all within the same country. The discussion concludes that each method has its strength; monetary valuations are necessary in some contexts, stakeholder preferences are paramount in others, but where objectivity is key, then assessment against independently defined targets should be the preferred method.

Keywords: Biodiversity valuation, conservation, Environmental Impact Assessment, floodplains, land use.

Introduction

The management of land and water in rural lowland floodplains in England has undergone considerable change over the past 60 years. Post WWII, publicly funded investments were made to protect farmland against flooding, thereby enabling land drainage to enhance agricultural production. Such schemes were designed to help meet policy objectives of reliable food supply at reasonable prices, fair rewards to those engaged in farming, and support for the rural economy (Morris 1992). More recently, changing priorities in rural and environmental policy, such as the EU Water Framework and Habitats Directives, the Common Agricultural Policy and government initiatives such as Making Space for Water (Defra 2004), are encouraging a re-appraisal of land management options for floodplain areas. Defra's strategy 'Making Space for Water' (Defra 2004) aims to deliver a more holistic and risk-driven approach to flood-risk management by adopting a whole catchment approach. Actions to reduce flood risk are combined with natural processes by, for example, widening river corridors or creating multi-functional wetlands in floodplains. Given these changing drivers, rural land use in floodplains has recently been shifting from predominantly agricultural production to types of land use that need less protection against flooding and can deliver multiple benefits, such as floodwater storage and enhancement of biodiversity.

The work described here is part of the research project Integrated Land and Water Management of Floodplains, funded by the UK Rural Economy and Land Use (RELU) programme. This project is exploring opportunities to integrate farming, nature conservation and flood management in lowland floodplain areas which were previously engineered for land drainage purposes.

An ecosystem services framework has been developed to analyse the impacts of changing land use on rural lowland floodplains. The concept of 'ecosystem functions' represents the capacity of natural processes to provide goods and services (items that confer benefit and advantage) to meet human needs, directly or indirectly (Turner *et al*. 2000; de Groot, Wilson & Boumans 2002; de Groot 2006; Brauman *et al.* 2007; Zhang *et al*. 2007). These ecosystem functions have the potential to deliver a range of ecosystem goods and services, but society determines the actual uses and the values derived from these. Examples of ecosystem services provided by floodplains are: agricultural production, hydrological regulation including floodwater storage, provision of habitat for wildlife, and space for living, recreation and amenity. Assigning values to the different ecosystem services is crucial in order to assess tradeoffs between ecosystem services under different floodplain management scenarios. Decision makers often call for these values to be expressed in money values so that they can be compared in a cost-benefit analysis. However, valuing ecosystem services that are non-market public goods (e.g. habitat, water quality, greenhouse-gas balance) is notoriously difficult. Various techniques have been developed for environmental evaluation and the aim of this paper is to assess the relative merits of various methods of valuing nature-conservation interests in floodplains.

Valuing nature-conservation interests

A number of different approaches can be taken to value the nature-conservation assets of an area. In this study, seven methods are tested and are summarised in Table 1: three derive values based on predefined priorities, two use the stated preferences of stakeholders, and two derive monetary values based on revealed and expressed preference. The rationale for selecting them is set out below.

Ecological Impact Assessment method

Ecological Impact Assessments (EcIA) are increasingly undertaken as part of the development control and planning process. In the UK there has been an attempt to standardise the approach taken by practitioners and this has led to the development of detailed guidelines such as those produced by the Institute of Ecology and Environmental Management (2006), which have built upon earlier work (e.g. Treweek 1999; Tucker 2005). EcIA guidelines state that the value, or potential value, of an ecological resource or feature should be determined according to its importance at a defined geographical scale; categories are identified, ranging from International Importance down to Parish /Neighbourhood Importance. The value of an ecological feature should then be measured against formal selection and prioritisation criteria. Extent of the feature, significance or importance, and threat status play a part in determining into which category an ecological feature should be placed.

Reserve-selection criteria

There is a wealth of scientific literature available on the process of assessing wildlife conservation potential for nature-reserve selection (e.g. see reviews in Van der Ploeg & Vlijm

1978; Margules & Usher 1981; Spellerberg 1992; Humphries, Williams & Vane-Wright 1995; Tucker 2005). The original basis for much of the reserve selection literature is Ratcliffe (1977) '*A Nature Conservation Review*' and this also formed the basis of the Guidelines for the Selection of Biological SSSIs (Nature Conservancy Council 1989). Ratcliffe (1977) identifies a number of different criteria for evaluating nature-conservation importance, which he divides into primary and secondary criteria. Although no standard set of criteria has emerged for the purpose of site evaluation, Ratcliffe's (1977) primary criteria have been commonly applied. They have been developed for evaluating existing wildlife sites, but most of the criteria can be adapted to evaluate potential value.

Targets based criteria

An alternative method of evaluating conservation projects is to measure proposed outcomes against national and regional targets. This is of particular relevance in the context of UK floodplains, as the UK government has recently produced new outcome measures and targets by which all proposed flood risk management projects should be evaluated. One of the principal outcome measures introduced will measure the hectares of priority Biodiversity Action Plan habitat created (Outcome Measure 5, Defra 2007, 2008). In addition, the UK statutory agencies have set a series of national and regional targets for each habitat and species in the UK BAP (UK BAP 2004, 2006).

Stakeholder choice analysis

The three previous techniques attempt to place a value on features using objective criteria and government-driven targets. However, value is inherently anthropocentric and it is likely that different stakeholders and interest groups perceive different values for the same features. There is a wide array of techniques pertaining to stakeholder choice analysis, although these have not been used widely in the conservation sector (but see Sinden and Windsor 1981; Anselin, Meire & Anselin 1989; Marsh *et al.* 2007).

Monetary valuations

The methods discussed above derive non-monetary values for nature-conservation interest. Valuing these in monetary terms is a notoriously difficult task, both philosophically and practically, but there is a burgeoning literature related to this (see for example Farber, Costanza & Wilson 2002; Milon & Scrogin, 2006; Mitsch & Gosselink, 2000;Turner *et al.* 2003; Yang *et al.*, 2008). Two such approaches are assessed; expenditure on agri-environment schemes and contingent valuation, which derive monetary values based on revealed and expressed preference respectively. It is noted, however, that the latter method, based on willingness to pay, can provide a more complete estimate of the welfare 'benefit' associated with increments of habitat quality compared with that based on the 'cost' of funding agri-environment schemes.

Methods

Study Sites

To test the methods in a range of situations, five lowland floodplain sites in England were selected to provide variation in climate, land use and water management regime (Figure 1 and Table 2). All had been the subject of land drainage improvement schemes prior to the 1980s and are predominantly under agricultural land uses (Morris and Hess, 1986).

Scenario development

For each study site, a number of potential land use scenarios were developed to simulate the land-use and habitats that would occur under different management regimes (Table 3). This approach allowed the valuation methods to be tested under a broader range of conditions than the present land use. The provision of ecosystem goods and services delivered under the different scenarios was measured using a set of key indicators. The methodology explained by Morris *et al*. (2008) was used to estimate the impacts of drainage conditions and flood probability on the physical productivity of farmland and hence financial returns (net margin, £ ha^{-1}) from land-based activities.

Valuing nature-conservation interests

Seven valuation methods were applied in order to assess the habitat conservation value of each scenario for each of the five floodplain sites. The methods are: Ecological Impact Assessment method, reserve-selection criteria, targets based criteria, stakeholder choice analysis, reserve-selection criteria guided by stakeholders, agri-environment scheme values, and contingent valuation (see further details below). When applying these methods, it was assumed that each management scenario had reached a quasi-equilibrium state in which full restoration of habitats, where applicable, had occurred. It should be noted that only habitats have been assessed, not their component species.

Ecological Impact Assessment method

Seven geographical categories of habitat importance were identified; International, National, Regional, County, District, Neighbourhood, and Non-priority. To assign an ecological feature to an appropriate category, a set of simple decision rules were developed based on a combination of conservation priorities and significance of the habitat. Conservation priority was established by consulting the EU Habitats Directive, Guidelines for the Selection of Biological SSSIs (Nature Conservancy Council 1989), the UK BAP, Regional and County BAPs, and Environmental Stewardship Targeting Statements. The latter provide land management priorities at a District level for all areas of England. Significance of the habitat was determined by calculating the proportion of the national and regional resource that occurred for each habitat type at each site, and particular site-specific features. The method is primarily designed to assess existing value, although it is recommended that where plans exist to create or enhance habitat within an area, it is appropriate to value the site as if the intended resource already existed. Predicted habitats were assumed to have been restored or created successfully.

Reserve-selection criteria

Definitions of the reserve-selection criteria selected in this project are explained in Table 4. For each criterion, a score out of 10 was developed.

Targets based criteria

Three simple indicators were produced here. The first was simply a measure of the area (ha) of priority Biodiversity Action Plan habitat created under each scenario (Outcome Measure 5, Defra 2007, 2008). The second and third were the percentage of national and regional targets respectively achieved by a scenario. The percentages of target achieved for each habitat type were then summed. This method assumed that all habitat targets were of equal importance.

Stakeholder choice analysis

Stakeholder preferences can be obtained through direct questioning. For this purpose, a workshop was held in April 2008 for stakeholders representing a wide range of interests in rural floodplain management. Two simple stakeholder choice exercises were carried out. First, a simple choice experiment was performed on five different habitats that could be created or restored on floodplain areas (all UK Biodiversity Action Plan priority habitats). Stakeholders were shown pairs of habitats and asked to allocate 10 points between each pair, based on the relative value that they placed on each. Information was also collected on the participants' familiarity with the habitats and their priorities and motivation in making their decisions.

Reserve-selection criteria guided by stakeholders

Second, stakeholders discussed and provided weightings for the reserve-selection criteria (Table 4) and were encouraged to suggest additional criteria. Stakeholders were divided into two groups, with one group containing biodiversity professionals and the other group containing non-biodiversity professionals, in order to determine whether preference varied accordingly. The new criteria identified were then applied to our study sites, together with the weightings for all reserve-selection criteria, to produce a new measure of reserve-selection criteria guided by stakeholders.

Agri-environment scheme values

In 2005, the UK government introduced a new agri-environment scheme known as Environmental Stewardship, with two tiers: the Entry Level Scheme (ELS) and the Higher Level Scheme (HLS). Agri-environment scheme values were calculated by determining the payments to farmers under each scenario through ELS and HLS (Defra 2005a, b). To be consistent with the other valuation methods, and to estimate farmer income, it was assumed that each proposed habitat is fully established and target species are present on site. Therefore, the annual payments for *maintenance* of a habitat type are used, rather than initial payments for *restoration* or *creation*.

Contingent valuation

The contingent valuation method was applied using the Environmental and Landscape Features (ELF) model developed by Oglethorpe *et al.* (2000), Hanley *et al.* (2001) and Oglethorpe (2005) to estimate the value of environmental features provided by agri-environment schemes in the UK. The ELF model is based upon the principle of benefits transfer, whereby a willingness to pay (WTP) function was derived from a large number of contingent valuation studies. By combining this with regional socio-economic data, different values were determined for different regions in England, and this has now been applied to seven different habitat types. Monetary values (WTP) for each habitat type in each region were obtained from the ELF model. The relevant monetary value was multiplied by the projected area of habitat for each scenario for each site to produce a mean WTP per hectare.

Results

Stakeholder workshop

As previously mentioned, a stakeholder workshop provided scores for two of the valuation methods. Using stakeholder choice analysis, lowland meadows attracted the greatest overall preference score (Table 5), with greatest preference given to floodplain habitats with high species-richness (lowland meadow, lowland fen and wet woodland) rather than habitats with lower species richness (reedbed and floodplain grazing marsh). The two groups of stakeholders ('biodiversity professionals' and 'non-biodiversity professionals') gave similar values for each habitat. Hence, the mean score for all participants was used in the stakeholder choice analysis of the scenarios.

Using the reserve-selection criteria guided by stakeholders, stakeholders identified three additional criteria that they felt important for assessing the value of habitats (Table 6). Overall, rarity, sustainability, connectivity and diversity were considered to be the most important criteria. The weightings given to each criterion are shown in Table 7.

Scenario outcomes

Though the underlying principles for each management scenario are the same, the outcomes vary per site, depending on predominant farming systems, soil type and climate. The principal habitat types predicted to occur under each scenario and the nature-conservation value derived using each method are shown in Table 8. As expected, a broad pattern of conservation values is apparent, reflecting the relative importance placed on conservation within a land use scenario. The *maximum production* scenario produces the lowest or equal lowest score for habitat conservation value under all of the scoring systems at all study sites. This is a little lower than the conservation value of the *current land-use*, and considerably lower than the values achieved under the biodiversity scenarios. The habitat conservation values achieved under both biodiversity scenarios are similar, with the highest score varying from site to site. The scenario of *maximizing biodiversity within an agricultural system* often scores the highest, primarily due to the high nature-conservation value of alluvial hay meadows.

Comparison of valuation methods

The outcomes of the different valuation methods are broadly consistent, and this is confirmed by a high degree of correlation between the different methods (Table 9). The only method with consistently weaker correlations is that using target-based criteria involving the area of BAP habitat created.

However, there are some differences, and these reflect the fact that each method is emphasising a slightly different aspect of conservation value. Contingent valuation places much greater value on wetland habitats (lowland fen and reedbed) and hence the scenario to maximize biodiversity outside of an agricultural setting is always ranked highest. On the other hand, the agri-environment scheme payments method does not value these habitats very highly and always ranks the scenario to maximize biodiversity within an agricultural context more highly. The ranking of the scenarios by the remaining methods is determined by site-specific characteristics, with reasonable consistency.

When comparing amongst sites, no site consistently achieves the highest habitat conservation score over several of the different valuation methods. Reserve-selection criteria guided by stakeholders, places a high emphasis on connectivity, which is highest at Cuddyarch Sough. Both the reserve-selection criteria and Ecological Impact Assessment Method are influenced by size, resulting in Beckingham Marshes (the largest site) scoring highly. Bushley is the smallest site but scores highest for stakeholder choice where size has no impact, and because lowland hay meadows are particularly highly valued. Agri-environment scheme payments favour floodplain grazing marsh for breeding waders, and so Sempringham Fen and Beckingham Marshes score highly here. Contingent valuation places much more value on fen and reedbed habitats, particularly in the East Midlands (where they are rare) and hence the Idle scores the highest using this method.

The five sites, each with five management scenarios, gave a total of 25 situations to assess. No two of the methods trialled gave identical rankings of these 25 situations in terms of value, showing that each may give rise to different judgements being formed.

Discussion

Seven different methods of valuing the nature-conservation interest of an area have been tested here. The methods gave broadly similar outcomes, but each method results in produced a slightly different relative scoring between habitat types' ranking of the scenario outcomes in terms of their nature-conservation value, as each method emphasised a different aspect of that value.

The general principles underlying the *Ecological Impact Assessment method* are well understood by ecological consultants and others in the conservation sector. By designing a set of simple decision rules, much of the subjectivity of this method could be removed and it should be repeatable. However, the large number of geographical categories into which a habitat can be placed is confusing, particularly as selection and prioritization criteria often overlap, and it would be sensible to reduce the number of categories. The EcIA approach appears to be able to differentiate well between scenarios, but inevitably relies on a degree of subjective judgment.

The *reserve-selection criteria* took some time to develop, as rules needed to be defined for each criterion, but subsequently was relatively quick and easy to apply. It is the most objective and repeatable of the methods tested here, it can be applied to future land use scenarios, and it uses well established criteria that have been used to evaluate nature-conservation interests over many years. It should be noted that the score is influenced by the size of the site, hence larger sites score relatively highly. It is insensitive to changes in biodiversity that only affect a small part of a site.

Reserve-selection criteria guided by stakeholders has the advantage of taking well-established criteria and then applying weightings to place greater emphasis on those considered most important. It is, therefore, a useful way of bringing policy makers and other stakeholders into the decision making process (see Marsh *et al*. 2007 for another example of this approach). Additional criteria suggested by stakeholders are clearly important, but were not so easy to define and apply, such as cultural history and sustainability, as they are subject to different interpretation by different stakeholders. Connectivity, although well known to be important, was difficult to measure in the context of our study, given the focus on individual sites. It is, however, potentially important, at the catchment scale. As before, this method was heavily influenced by the size of the site, and was insensitive to high biodiversity value in just a part of the site.

Three different *target based criteria* were tested. Area of priority BAP habitat created was insensitive to the different scenarios, with all scenarios either scoring zero or maximum. However, it is a quick, easy, objective and repeatable method and potentially useful where different sites are being compared. The percentage of national and regional targets relied upon the assumption that all habitat creation targets were equal, which is unlikely to be the case. Furthermore, the specification of regional targets, in particular, is not consistent from region to region, and some habitats have been treated very differently to others in the BAP process. Very high scores were achieved in some regions due to the unambitious level of targets set. There appears to be some inconsistency in the production of BAP targets, which would need to be addressed if they were to be used more widely in land-use planning. The method has the most potential for objective assessment, but only where targets have been set consistently and independently across the entire area of study.

Simple stakeholder choice resulted in a straightforward and easy to apply index by which the scenarios could be evaluated. This method provides a useful indication of the opinions of stakeholders towards different habitat types, although stakeholders are inevitably influenced by the information presented to them. Workshop participants also commented on the difficulty of valuing habitats out of context and stated that they would favour habitats that were most appropriate to each particular study site. The approach could be extended by assessing stakeholder value of semi-natural habitats compared to improved farmland habitats. The method can also incorporate the preferences of local stakeholders, a critical element of sustainable development.

Assessing value through *agri-environment scheme payments* is a useful approach as uptake of schemes by farmers is likely to be heavily influenced by the effect on their income. It is transparent, easy to apply and easily repeatable. However, there is not a clear link between agri-environment payments and the value of ecological outcomes. Agri-environment payments are predominantly cost rather than benefit based indicators of value, largely reflecting 'compensation' for farmers for income lost from conventional farming. Furthermore, payment regimes do not appear to reflect the values revealed by the other methods. For example, a farmer might receive £335 ha^{-1} annually for managing land as floodplain grazing marsh for the benefit of breeding waders, but only £60 ha^{-1} for managing it as reedbed or lowland fen (Defra 2005b). Yet all other valuation methods place a greater value on fen than on floodplain grazing marsh. The low payments for the maintenance of fen or reedbed habitats undervalue their potential contribution to valuation by this method compared to the others.

The final method (*benefits transfer of contingent valuation studies*) provides some indication of the monetary value that society places on the ecological services provided by different habitats. It is easy to apply and repeatable, using the Environmental and Landscape Features model (Oglethorpe *et al.* 2000; Hanley *et al.* 2001; Oglethorpe 2005). However, the model itself is dependent upon a whole array of assumptions embedded within the original estimates and in the process of transferring these estimates to other sites. In addition, the habitats in the ELF model are broader than those being used in our study, and include improved habitat types with a lower ecological value. It is therefore likely that this method underestimate values, particularly for the hay meadow and rough grazing categories. Thus, the monetary values produced should be treated with caution, but nevertheless provide indicative relative values for comparison with the other methods. Interestingly, this method places a much greater value on wetland habitats (fen and reedbed) than the other methods assessed, which reflects the findings of other monetary valuation studies. The actual values are considerably lower than the monetary values determined by agri-environment scheme payments as this method is valuing only one non-market good (environmental features). Other studies (see reviews in Brouwer *et al*. 1999; Woodward & Wui 2001; Eftec & Entec 2002; Brander, Florax & Vermaat 2006) reveal that if all externalities are valued then wetlands and other semi-natural habitats have an extremely high monetary value. The choice of technique therefore needs to reflect the type of value being measured and this selection needs to be stated explicitly.

It is encouraging that the valuation methods provide broadly similar outcomes. The reserve selection criteria, reserve selection guided by stakeholders, and the Ecological Impact Assessment method in particular, give similar results. However, the exact outcome depends on the criteria and underlying assumptions of the valuation method chosen. It is clearly difficult to get one objective and comprehensive value for nature-conservation and different methods may be appropriate in different situations. Where monetary values are required to integrate with other financial criteria, then the agri-environment-scheme approach or contingent valuation are the most appropriate, where the views of stakeholders are paramount, then a stakeholder choice technique or stakeholder-derived criteria are best, but if objectivity is the aim, then Ecological Impact Assessment or target-based criteria are most suitable. It is considered that the latter would be the most objective, but only when a common set of targets have been independently set across the area being assessed.

Ecologists are increasingly called upon to value the biodiversity of a site or to compare the value of different sites. Although this task is inherently difficult to achieve, it is important that robust results are produced and that these can be compared with different assessment criteria and by people working in different subject areas. Such results can then be used to inform multi-criteria decision analyses, cost-benefits analyses and other integrated ecological and economic modelling (e.g. Weber, Fohrer & Möller 2001; Münier, Birr-Pedersen & Schou 2004; Santelmann *et al.* 2004; Prato & Herath 2007). The seven methods tested represent a wide range of techniques that have previously been used to determine nature-conservation value. Comparison of different methods, such as the analysis presented here, is necessary to inform the debate over nature-conservation valuation and will be of interest to the fields of land-use planning, reserve selection, Environmental Impact Assessment and wherever an integrated approach to land management is required. Our conclusion is that each method has its strengths and may be appropriate in particular situations. However, with a multiplicity of methods, cross-project comparisons are difficult, even impossible. The outcome of a valuation technique is clearly influenced by the assumptions made. These assumptions need to be explicitly stated such that cross-project comparisons can be undertaken and, as the field continues to develop a consensus may emerge in terms of the preferred techniques for general application to each type of situation.

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Table 1. Summary of the seven methods used to value floodplain habitats

Method	Approach	Decision criteria	Outputs	Key references
Ecological Impact Assessment method	Assessed using pre-defined prioritization criteria	Designation status of the habitat, proportion of national and regional resource	Non-monetary score	Treweek (1999), Tucker (2005), Institute of Ecology and Environmental Management (2006)
Reserve-selection criteria	Valued using ecological criteria pre-determined by experts	Diversity, rarity, naturalness, size and fragility	Non-monetary score	Ratcliffe (1977), Margules & Usher (1991)
Targets based criteria:	Assessed against government targets	Net area of priority BAP habitat created; percentage of national and regional targets created	Area; % of targets	Defra (2007), UK BAP (2004, 2006)
Stakeholder choice analysis	Expressed preferences of a range of stakeholders	Stakeholder preferences for key habitats, based on a wide range of criteria such as biodiversity, rarity, aesthetics, cultural history and personal preference	Non-monetary score	Sinden & Windsor (1981), Anselin, Meire & Anselin (1989)

Reserve-selection criteria guided by stakeholders	Uses stakeholders to guide and provide weightings for expert-derived criteria	Reserve selection criteria, plus additional criteria identified by stakeholders. Relative importance weighted by stakeholders	Non-monetary score	Marsh *et al.* (2007)
Agri-environment scheme values	Revealed, expenditure based preference for different habitats	Money payable to farmers and land managers through agri-environment schemes	Monetary value	Pretty *et al.* 2000, Farber, Costanza & Wilson (2002), Defra (2005a, b)
.Contingent valuation	Benefits transfer of willingness to pay (expressed preference)	Members of the public willingness to pay for environmental goods, adjusted by socio-economic factors	Monetary value	Oglethorpe *et al.* (2000), Hanley *et al.* (2001), Oglethorpe (2005)

Table 2. Location, geo-physical and current land-use information for each study site.

Site	**Beckingham Marshes**	**Idle**	**Cuddyarch Sough**	**Bushley**	**Sempringham Fen**
County	Nottinghamshire	Nottinghamshire	Cumbria	Worcestershire	Lincolnshire
Region	East Midlands	East Midlands	North West	West Midlands	East Midlands
River	Trent	Idle	Wampool	Severn	South Forty Foot Drain
Annual rainfall (mm)	599	640	1003	622	574
Soil association	Fladbury (heavy clay)	Altcar (fen peat), Newport (loam), Enborne (loamy clay)	Rockcliffe (alluvial soil)	Hollington (silty clay loam)	Wallasea (silty clay)
Current farming system	Extensive arable, beef	Dairy, intensive arable	Dairy, beef	Extensive arable	Extensive arable
Current land cover	Cereals, oilseed rape, grassland	Grass, root crops (onion, carrot, potato), cereals	Grassland, cereals	Cereals, grass, oilseed rape	Cereals, oilseed rape
Size (ha)	919	303	282	146	820

Table 3. Scenarios developed to investigate land and water management in rural floodplains.

Scenario	Definition
Current situation	Based on farmer interviews and ecological surveys carried out in 2006-7
Maximum agricultural production	Comprises intensive agricultural land use, which was originally the objective when the land drainage of these floodplains was improved. The land use is defined by soil, climate and current and past land use patterns. The water management regime is characterised by rapid drainage and controlled low flood frequency.
Maximum biodiversity within an agricultural system	Seeks to enhance biodiversity with the imposed constraint that the predominant land use remains agriculture. Land use options are selected that are promoted by current agri-environmental schemes, in particular the Higher Level Stewardship Scheme (Defra, 2005b). The water management regime depends on the tradeoffs between the requirements for agriculture and wet habitats, but typically consists of medium duration flooding and moderate drainage. Local soil conditions, topography and historical context, together with local and regional conservation and land-use priorities have been used to determine the specific habitat types that would be created.
Maximum biodiversity outside of an agricultural system	Seeks to enhance biodiversity, without any imposed constraints, guided by local and national Biodiversity Action Plan targets. The water management regime is characterised by frequent flooding and slow natural drainage. The same criteria are used for determining the habitat types as for the previous scenario.
Maximum farm income	Seeks to maximise the income derived from the land based on 2006 prices for agricultural produce and payments received through Environmental Stewardship if applicable. The land use for this scenario is determined by

one of the previous scenarios with the highest estimated profitability (net margin) for land management.

Table 4. The reserve-selection criteria assessed (based on Ratcliffe 1977).

Criteria	**Comments**
Diversity	This is one of the most frequently used evaluation criteria. As is commonly the case, species richness was used as a surrogate for diversity. For semi-natural habitats, typical plant species richness per sampling unit was obtained for each plant community from published NVC floristic tables (Rodwell 1991-2000). For intensive arable habitats, average plant species diversity measured in the Countryside Survey 2000 was used (JNCC 2007). Diversity was then scored as the species richness of the projected habitat compared to the maximum species richness of habitats that could be created at that site.
Rarity	Rare species and habitats are given greater priority and sites that contain a large number of rare species are particularly important. Information was collected on the total resource of each habitat type in England for agricultural (Defra 2006) and natural (Natural England 2008) areas. A rarity index was then developed based on the total amount of each habitat type in England.
Naturalness	There is much debate over the definition of this term, and particularly its relationship with ‘wildness’ (Margules & Usher 1991; Ridder 2007). Almost all habitats in the UK and Europe, including those with high ecological, cultural and aesthetic value, are modified by man to at least some extent. Anderson (1991) suggests three components of naturalness: • Degree to which system would change if humans were removed. • Amount of energy required to maintain that habitat. • Complement of native species.

	Following Anderson (1991), a score was developed for each habitat type based on the degree to which the habitat would change if humans were removed, the amount of energy required to maintain that habitat (low energy being more natural), and the complement of native species.
Size	Larger sites are generally more highly valued as many species require a minimum area to support a minimum viable population or metapopulation. Larger sites typically contain a greater diversity of habitats and species, have reduced edge effects, and are buffered against environmental stochasticity. Size was defined as the area (3.33 x $\log_{10}$ hectares) of the habitat that was present or would be created at each site, scaled such that an area of 1000 ha would score the maximum 10 points.
Fragility	Habitats or species that are highly sensitive to human disturbance or change are more highly valued. This is strongly linked with the concept of re-creatability – how difficult it is to re-create a habitat. This is considered to be the best single measure of nature-conservation value when selecting biological SSSIs (Nature Conservancy Council 1989). The fragility score was based on expert judgement of how many years it would take to restore or create that habitat, moderated by how difficult the process was to achieve. Creation was assumed to have occurred once a simple working functional habitat type could be produced, rather than a habitat with fully restored species diversity.

Table 5. Mean scores (out of 10) given by stakeholders for different habitat types in a simple choice experiment.

Habitat preferences	**Biodiversity professionals (n = 8)**	**Non-biodiversity professionals (n = 10)**	**All (n =18)**
Lowland meadows	6.03	5.83	5.92
Lowland fen	5.78	5.45	5.60
Wet woodland	4.97	4.73	4.83
Reedbed	4.34	4.35	4.35
Floodplain grazing marsh	3.88	4.65	4.31

Table 6. Additional criteria identified by stakeholders

Criteria	**Definition and rationale**	**How measured**
Cultural history	Particularly valued by the group of non-biodiversity professionals, this places high value on habitats that would have been common on traditionally managed rural floodplains prior to industrialisation. Often refereed to as the 'rural idyll'.	Score out of 10 with maximum score for habitats produced by traditional low-intensity agricultural practices.
Sustainability	Indicates how easily a habitat type can be maintained. Non-biodiversity professionals placed low value on habitats that required extensive ongoing management.	A score was developed based on how easily the habitat could be maintained combined with the annual use of energy.
Connectivity	Connectivity relates to the amount and pattern of habitat patches within the wider landscape. Methods of measuring connectivity are reviewed by Moilanen & Nieminen (2002). Regarded as important by both stakeholder groups.	Difficult to measure given a lack of detailed habitat information from the wider area. Score derived from the total area of land of each habitat type, combined with distance to nearest neighbour outside of the site.

Table 7. Overall weightings (out of 100) given to the reserve-selection criteria and the additional criteria identified by the stakeholders (n = 13).

Criteria	**Mean weighting**
Primary reserve-selection criteria:	
Rarity	20.3
Diversity	14.0
Size	9.5
Fragility	8.1
Naturalness	6.3
Additional criteria identified by stakeholders:	
Sustainability	18.9
Connectivity	17.6
Cultural history	5.4

Table 8. Predicted habitat types and conservation values using different valuation methods for five alternative land-use scenarios on five floodplain study sites (maximum values shown in bold).

Method	Units	2006	Max production	Biodiversity within agriculture	Biodiversity outside agriculture	Max income
Beckingham Marshes						
Principal habitat types[a]		C,GM	C,RC	GM,FM	R,WW,GM	GM
EcIA method	mean score ha^{-1}	1.32	1.01	**5.82**	5.07	4.60
Reserve-selection criteria 1	mean score ha^{-1}	1.63	1.58	**3.26**	2.97	2.37
Reserve-selection criteria 2	mean score ha^{-1}	3.97	3.80	**6.71**	6.27	5.53
Simple stakeholder choice	mean score ha^{-1}	0.00	0.00	**5.05**	4.49	4.30
Agri-env scheme payments	£ ha^{-1}	50	0	299	219	**364**
Contingent valuation	£ ha^{-1}	0.98	0.17	18.15	**43.98**	5.07
Area of BAP habitat created	ha	na	-10	**901**	**901**	**901**
Percentage of national targets	%	na	0	**64.7**	26	8.4
Percentage of regional targets	%	na	0	125.2	**216.9**	91.9
Idle						
Principal habitat types[a]		C,RC,IG	C,RC,IG	GM,FM,HM	LF,R,HM	RC,C,IG
EcIA method	mean score ha^{-1}	2.18	1.01	4.87	**5.38**	1.03
Reserve-selection criteria 1	mean score ha^{-1}	1.67	1.57	3.12	**3.28**	1.61
Reserve-selection criteria 2	mean score ha^{-1}	4.17	3.90	6.43	**6.63**	3.94
Simple stakeholder choice	mean score ha^{-1}	0.00	0.00	**5.22**	5.13	0.00
Agri-env scheme payments	£ ha^{-1}	30	0	**282**	117	30
Contingent valuation	£ ha^{-1}	0.22	0.17	21.39	**78.60**	0.26
Area of BAP habitat created	ha	na	-3	**297**	**297**	2
Percentage of national targets	%	na	0	**25.4**	22.4	0
Percentage of regional targets	%	na	0	40.8	**62.2**	0

Bushley						
Principal habitat types[a]		C,IG	RC,C,IG	FM,GM	FM,R,WW	IG,RC
EcIA method	mean score ha^{-1}	1.14	1.04	**5.68**	4.54	1.05
Reserve-selection criteria 1	mean score ha^{-1}	1.41	1.37	**3.43**	2.61	1.70
Reserve-selection criteria 2	mean score ha^{-1}	3.59	3.46	**6.50**	5.57	3.93
Simple stakeholder choice	mean score ha^{-1}	0.05	0.05	**5.35**	4.42	0.05
Agri-env scheme payments	£ ha^{-1}	30	0	**268**	256	14
Contingent valuation	£ ha^{-1}	0.29	0.28	19.64	**48.67**	0.30
Area of BAP habitat created	ha	na	0	**144**	**144**	0
Percentage of national targets	%	na	0	**13.8**	3.5	0
Percentage of regional targets	%	na	0	**341.7**	69.4	0
Sempringham Fen						
Principal habitat types[a]		C	C, RC	GM,HM	LF,R,GM	GM
EcIA method	mean score ha^{-1}	1.01	1.00	5.16	**5.62**	4.64
Reserve-selection criteria 1	mean score ha^{-1}	1.61	1.55	2.72	**3.15**	2.36
Reserve-selection criteria 2	mean score ha^{-1}	3.90	3.76	5.24	**6.00**	4.72
Simple stakeholder choice	mean score ha^{-1}	0.02	0.00	4.59	**4.85**	4.30
Agri-env scheme payments	£ ha^{-1}	30	0	339	139	**350**
Contingent valuation	£ ha^{-1}	0.29	0.05	10.00	**74.49**	5.06
Area of BAP habitat created	ha	na	-3	**815**	**815**	**815**
Percentage of national targets	%	na	0	27.7	**41.6**	0
Percentage of regional targets	%	na	0	107.7	**163.3**	0
Cuddyarch Sough						
Principal habitat types[a]		IG,C,FM	IG	FM,PMG, GM	WW,PMG, FM,LF,R	IG
EcIA method	mean score ha^{-1}	1.32	1.02	**5.77**	5.16	1.02
Reserve-selection criteria 1	mean score ha^{-1}	1.95	1.91	**3.60**	**3.60**	1.91
Reserve-selection criteria 2	mean score ha^{-1}	4.61	4.54	6.73	**7.20**	4.54
Simple stakeholder choice	mean score ha^{-1}	0.38	0.00	**4.94**	4.92	0.00

Agri-env scheme payments	£ ha^{-1}	42	0	**254**	233	30
Contingent valuation	£ ha^{-1}	2.35	0.70	14.27	**26.67**	0.70
Area of BAP habitat created	ha	na	0	**280**	**280**	0
Percentage of national targets	%	na	0	**54.3**	29.4	0
Percentage of regional targets	%	na	0	**798.8**	380.6	0

[a] Principal habitat types are coded as follows: C = cereals, RC = root crops, IG = improved grassland & leys, GM = grazing marsh, FM = floodplain meadow, HM = hay meadow, R = reedbed, LF = lowland fen, PMG = purple moor grass & rush pasture, WW = wet woodland.

Table 9. Correlations between the different valuation methods for 5 scenarios at 5 sites.

	Valuation Method							
	EcIA method	Reserve selection 1	Reserve selection 2	Stakeholder choice	Agri-env. values	Contingent valuation	BAP area created	National targets
Reserve selection 1	0.880***	-	-	-	-	-	-	-
Reserve selection 2	0.870***	0.985***	-	-	-	-	-	-
Stakeholder choice	0.888***	0.843***	0.818***	-	-	-	-	-
Agri-env. values	0.814***	0.751***	0.763***	0.755***	-	-	-	-
Contingent valuation	0.834***	0.885***	0.876***	0.848***	0.741***	-	-	-
BAP area created	0.765***	0.661**	0.687**	0.660**	0.849***	0.685**	-	-
% national targets	0.917***	0.881***	0.877***	0.841***	0.686**	0.762***	0.794***	-
% regional targets	0.869***	0.878***	0.853***	0.781***	0.697**	0.724***	0.725***	0.900***

Correlations are Spearman's rank correlation coefficients (n = 25). The r_s values and the associated *P*-values (** $P < 0.01$, *** $P < 0.001$) are shown.

Fig. 1. Map showing the location of the study sites